Resource Action: EWG-16B **Task Force Recommendation Category:** 2

Proposed Restoration/Improvement of Rearing Habitat for Juvenile Salmonid Fish Species

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Description of Potential Resource Action Measure:
Restore and/or improve side-channel habitat adjacent to the low-flow channel (LFC) in the Feather River. The two existing side channels at the upstream end of the LFC, Hatchery Ditch and Moe's Ditch, would benefit from habitat and flow enhancements. Hatchery Ditch, a primary steelhead spawning and rearing reach, is currently fed solely by seepage from the Feathery River Hatchery (FRH) settling pond. Discharge in Hatchery Ditch is directly related to water use in the hatchery. Hatchery Ditch requires its own water source for several reasons. First, there may be water quality issues associated with the FRH effluent. Second, chemical/olfactory attraction from the Feather River hatchery effluent may result in stacking up of steelhead spawners and superimposition of redds. Third, seepage from the settling pond percolates through the levee, which may cause damage to the levee. And finally, the ditch needs to be able to function independently of the FRH to allow maintenance on the FRH flowline. This need is particularly pressing since the FRH flowline is overdue for a major overhaul, which requires shutting down the hatchery water supply for several months.

Moe's Ditch is an artificial spawning channel adjacent to Hatchery Ditch. Currently Moe's Ditch lacks flow due to upstream changes in bed morphology, a lack of cover and lack of channel sinuosity.

There are several other Resource Action that are either similar to or otherwise related to this measure:

- EWG-13A and EWG-13B, proposed to improve rearing habitat in the low flow reach through placement of wood and other materials.
- EWG-16A proposing creation of side channel habitat in the low flow reach.
- EWG-17 and EWG-51, that would enhance riparian vegetation to increase shading and habitat complexity.
- EWG-89, that would involve levee setbacks and increase floodplain accessibility to the river.
- EWG-19A and EWG-22, proposing levee setbacks and/or geomorphic restoration in the lower Feather River to improve connectivity between the river and its floodplain.

Nexus to the Project:
Many factors, including flood control levees, construction of the dam at Lake Oroville and regulation of stream flows have cumulatively caused changes in the geomorphology and substrate of the Feather River. These changes have generally reduced the availability of spawning and rearing habitat for anadromous fishes.

Potential Environmental Benefits:
The most immediate potential benefit of the proposed Resource Action is an increase in rearing habitat for juvenile salmonids, but the primary potential benefit is an increase in the escapement levels of naturally produced steelhead trout and spring-run and fall-run Chinook salmon in the Feather River. Hatchery production of anadromous salmonids has a number of potential adverse effects on wild populations of these fish, so natural production should be favored whenever feasible. The majority of young-of-the-year steelhead and salmon found during recent surveys by DWR fisheries biologists were observed or captured in the upstream reach of the LFC (Study Plan, SP-F10 - January 22, 2003 Interim Report). Hatchery Ditch had by far the highest density of juvenile steelhead of any of the sampled sites. Given the importance of Hatchery Ditch and other areas within the upstream reach for salmonid production, rearing habitat in this reach is particularly important.

Secondary benefits of the proposed Resource Action include an increase in the forage base of striped bass, Sacramento pikeminnow and other predators of juvenile salmonids; an increase in habitat for riparian plant and wildlife species; and an increase in the aesthetic value of the river corridor.

Potential Constraints:
There are two major constraints to this measure. The first pertains to the sustainability of any habitat improvements in Moe's Ditch. The ditch has a history of improvements to enhance spawning habitat. These improvements included placement and raking of gravels. High flows through the ditch periodically flushed gravels from the ditch, necessitating repeated replacements. It is probable that new improvements to the ditch would only provide short-term benefits. This issue is discussed further, below.

The second constraint applies to diversion of water from the LFC to Hatchery Ditch or to Moe's Ditch. This would probably entail a reduction in flows unless mandated releases are augmented to accommodate the measure. Depending on the quantity of flow diverted, there could be impacts on habitat values in the LFC.

Existing Conditions in the Proposed Resource Action Implementation Area:
Because of water temperature constraints, the LFC is currently the only portion of the lower Feather River suitable for year-around rearing of juvenile salmonids and is, by far, the most important section of the river for salmon and steelhead spawning. However, habitat with suitable depth, cover and flow velocity conditions for rearing salmonids is limited in the LFC. Rearing habitat in the LFC is particularly important for steelhead, which generally rear one to two years before emigrating to sea. Most Feather River

chinook begin their emigration within a month or two of emerging from their redds. However, with more favorable rearing habitats the residency period of Chinook salmon could probably be increased.

Juvenile steelhead and Chinook salmon have similar rearing habitat needs. DWR fisheries surveys found juveniles of both species primarily in glide habitats with instream cover and/or overhead cover (e.g., canopy) (SP-F10 January 22, 2003 Interim Report). Most were found at shallow depths within a couple of meters of the shore. The juveniles of both species gradually shifted to greater use of riffle habitat with higher flow velocities as they grew larger, although the shift was somewhat more pronounced for steelhead than for salmon. Habitat with moderate flow velocity provides the juvenile salmonids with good feeding conditions, and shallow depth and abundance of cover provide refuge from predators. In large, low gradient rivers like the lower Feather River, side channels and tributaries typically provide the sort of riffle/glide, near-shore habitat with abundant cover that juvenile salmonids prefer. Such habitats are uncommon in the LFC.

The LFC of the Feather River can be divided into three reaches on the basis of habitat types. The upstream reach, from River Mile (RM) 67, below the Fish Barrier Dam, to the Highway 70 bridge (about RM 65.6), has a complex mix of riffle, glide and pool habitat, interspersed with a number of gravel mid-channel bars and channel side bars. Riparian vegetation is moderately well developed in portions of this reach. Hatchery Ditch and Moe's Ditch are in the upstream portion of this reach. The middle reach of the LFC, which stretches from the Highway 70 bridge to Robinson Riffle at RM 62, has little gradient and is largely comprised of long, deep pools with highly uniform habitat conditions. Most of the riverbank in this reach is straight and steep and has little riparian vegetation. The only exception is an approximately one-mile section downstream of the Highway 162 bridge that includes three riffle/glide areas (Trailer Park Riffle, Mathews Riffle and Aleck Riffle). Little side channel habitat occurs in the middle reach of the LFC. The downstream reach of the LFC extends about 2.5 miles from Robinson Riffle to Gateway Riffle. This reach includes a series of pool, riffle and glide habitats. Gravel bars and mid-channel islands with riparian vegetation are common in this reach and side channel habitat is more plentiful in this reach than in either of the other reaches.

The distribution of rearing young-of-the-year salmonids in the LFC did not match the distribution of side channel habitat. Although side channel habitat is most plentiful in the downstream reach, the majority of young-of-the-year steelhead and salmon found during the DWR fisheries surveys were observed or captured in the upstream reach of the LFC (SP-F10 January 22, 2003 Interim Report). As previously noted, Hatchery Ditch had by far the highest density of juvenile steelhead of any of the sampled sites. The authors of the SP-F10 report speculate that the upstream distribution of the young-of-the-year steelhead results from greater spawning by adult steelhead in the upstream reach. They suggest that the blockage of migrating fish by the Fish Barrier Dam and chemical/olfactory cues from the Feather River hatchery effluent cause most steelhead

to spawn in the upstream reach. This spawning distribution would explain the concentration of recently emerged fry in the upstream reach. In contrast to young-of-the-year steelhead, age-1 and older juvenile steelhead distribution did match the distribution of side channel habitat.

Hatchery Ditch is a narrow, shallow, heavily shaded channel that runs along the base of the levee separating the FRH from the LFC (Figures 1 and 2). Well-developed riparian vegetation, including a number of large cottonwood trees, borders the ditch, affording it excellent cover. Flow velocity in much of the ditch was moderately high. Most of the channel has clean gravel substrate and the ditch is heavily used for spawning by steelhead (Jason Kindopp, DWR, personal communication). Inspection of the substrate during the field visit revealed many benthic macroinvertebrates. A long gravel bar lies between Hatchery Ditch and the main channel of the river. Moe's Ditch sits on this bar.

As previously indicated, seepage from the Feather River Hatchery (FRH) settling pond is the sole source of flow to Hatchery Ditch. Prior to the 1997 flood, Hatchery Ditch apparently had less flow and the flow percolated into the gravel, so the ditch was not connected to the river (Koll Buer, DWR, personal communication). It appears that the flood opened the channel and may have affected the levee, increasing the rate of seepage from the settling pond into the ditch (Jason Kindopp, DWR, personal communication). Currently, discharge in Hatchery Ditch is directly related to water use in the hatchery. During the field visit to the site, the settling pond retained little of the water discharged into it and the water appeared to seep rapidly through the levee into Hatchery Ditch (Figure 3). Several large, rapidly flowing seeps were found at the base of the levee near the upstream end of the ditch (Figure 4). The elevation of the channel in this area was several feet higher than that of the river. Because Hatchery Ditch does not get its flow from the river channel and because its upstream end has a higher elevation than that of the river channel, it currently functions more like a tributary than a side channel.

Moe's Ditch is a broad, straight, exposed man-made channel adjacent to Hatchery Ditch (Figures 1 and 5). The channel was initially constructed in the 1970s to enhance salmonid spawning. The ditch has been regraded many times and complete reconstruction has been required after several flood events. The ditch was adversely affected by the 1997 flood and currently provides little spawning or rearing habitat. Young willows border much of the ditch, but they provide little cover.

Moe's Ditch begins at the upstream end of Auditorium Riffle and flows downstream over the gravel bar for about 1/7th of a mile, where it discharges back to the river. The upstream end is clogged with gravel that restricts flow in the channel. Apparently, such blockage has been a frequent problem for the channel (Koll Buer, DWR, personal communication). Because of the low flow, shallow depths and exposure, substrate at the upper end of Moe's Ditch is blanketed with algae. Beavers have constructed a dam near the lower end of the ditch; so much of the channel has been converted into a pool.

Because of low flow, vegetation is heavily encroaching into the channel at the downstream mouth of the ditch (Figure 5).

Design Considerations and Evaluation:
The most important design consideration for restoring and improving rearing habitat in Hatchery Ditch and Moe's Ditch concerns the flow regime of the river. Habitat improvements made in these channels would likely be altered or destroyed by flood flows. The Oroville Project is currently operated to maintain relatively low, uniform flows through the LFC. High flows occur only during periods of extreme runoff. Therefore, habitat improvements in these channels have a high probability of persisting for several years with the current flow regime, although regular maintenance would likely be required. However, project operations could be altered to more closely mimic a natural flow regime, with frequent periods of high flow and periodic flood events. Frequent high flow events would likely alter or destroy habitat improvements or eliminate the channels entirely, defeating habitat restoration and improvement efforts. However, frequent high flows could lead to the formation of natural side channel habitats, particularly if some levees were breached to increase the area of flood plain. Ultimately, this might reduce the need for improving existing rearing habitat.

The most critical habitat improvement need for Hatchery Ditch is to provide a source of water other than the current FRH source. The current situation is unsustainable because of potential water quality issues, over-attraction of steelhead spawners, levee damage, and pressing FRH flowline maintenance needs. Because the upstream end of the Hatchery Ditch channel sits at a higher elevation than that of the adjacent river channel, flow cannot be provided to the ditch by breaching the bar that separates the two channels. Two alternatives have been proposed for diverting river water into the channel. One solution would be to pump water from the river into the upstream end of the channel. The channel currently receives up to 25 cfs, which would require a large pump, but less flow may suffice (Jason Kindopp, DWR, personal communication). In any case, the pump would be too large to be portable and would therefore have to be installed well above flood stage. Other potential solutions would be to construct a flowline to divert water from an upstream location in the main river channel or from the Fish Barrier Dam pool. All of these alternatives would be costly.

Most physical habitat conditions within the Hatchery Ditch channel appear to be good for salmonid rearing habitat. As described earlier, rearing juvenile salmonids favor habitat with moderate flow velocities, shallow depths, and abundant instream and overhead cover. Average focal point velocities for juvenile steelhead in the LFC increased with size of the fish from less than 0.1 feet per second (ft/s) to about 2 ft/s (SP-F10 January 22, 2003 Interim Report). Average depth ranged from about 0.2 to 0.4 meters and average distance from shore ranged from less than half a meter to about 2 meters. Microhabitat parameters for juvenile Chinook salmon were similar. The juveniles of both species were associated with small instream cover and overhead cover, but avoided large instream objects. The large instream objects were probably avoided because of their potential for sheltering predators. The Hatchery Ditch channel

is heavily shaded and is well provided with instream and overhead cover (Figure 1). The channel is generally less than half a meter deep and less than three meters wide, so rearing juveniles are never far from the stream bank. However, during the field visit, flow velocities in some sections of the channel appeared to be high for small young-of-the year salmonids. These sections were relatively straight with uniform substrates and the flows were uniform and swift, providing few flow velocity refuges for small fish (Figure 4). Introducing instream structures in these sections would produce flow breaks that would likely improve the habitat.

Juvenile steelhead collected in Hatchery Ditch typically had full stomachs, so feeding conditions are probably adequate (Jason Kindopp, DWR, personal communication).

Habitat conditions in Moe's Ditch contrast sharply with those in Hatchery Ditch. Moe's Ditch is quite broad and has little flow. A beaver dam backs up the flow in much of the channel, creating a large area of pool habitat. The most immediate need for restoring habitat in Moe's Ditch is to remove the gravels that restrict flow from the river channel. If the channel was opened the flow entering the ditch might wash out the beaver dam. Otherwise the dam would have to be removed mechanically.

The broad channel of Moe's Ditch is suitable for spawning habitat, which was the original objective of the habitat design, but it is too exposed to provide good rearing habitat. A new, narrower channel in the same area would provide better rearing habitat and would be easier to maintain with adequate flows. In addition, a narrower channel could more easily be routed through existing riparian vegetation or be enhanced with vegetation improvements to provide instream and overhead cover. Finally, a narrow channel could be provided with meanders to create more habitat complexity, including variable flow velocities. Hydraulic modeling could be used to help design a channel producing flow velocities and depths suitable for rearing salmonids.

Implementing this measure would require permits from the Department of Fish and Game, Army Corps of Engineers and State Water Quality Control Board. Restoration of Moe's Ditch habitat would require moving large volumes of gravel using heavy earth-moving equipment. Such activities have the potential to produce water quality problems, particularly high turbidity. Therefore, the earth-moving activities should be restricted to a time of year when sensitive life stages of the salmonids are least abundant in the river. Spring-run Chinook salmon spawn from about mid August through October, fall-run chinook spawn from about September through December, and steelhead spawn from about November through June. Fry of all three species emerge from their redds in the late winter or spring and most of the salmon have emigrated by June. Therefore, July through mid-August is probably the best period of the year for avoiding impacts on sensitive life stages of these species. In addition, the July to mid-August period has little rainfall and low river flows, so mobilization of disturbed sediments would be minimized at this time.

The success of habitat restoration and improvement in Hatchery Ditch and Moe's Ditch would be judged on the basis of numbers and growth rates of juvenile salmonids found in the channels several years after the habitats were restored.

Synergism and Conflicts:
There are potential synergisms that would occur if side channel habitat creation is coordinated with other Resource Actions proposing geomorphic restoration in the low flow channel (e.g., EWG-89), spawning habitat improvement (e.g., EWG-18/90), placement of large woody debris and other structures (EWG-13A and 13B) and gravel placement (e.g., EWG-92). Coordination with riparian vegetation enhancement and restoration measures would also be beneficial.

Coordinating side channel habitat improvements with measures that propose changes in the flow regime would be essential. This could avoid or at least partially offset potential adverse effects on the LFC. Also, proposals for periodic peak flow releases would need to consider potential impacts on side channel construction projects.

Potential water quality conflicts could arise due to equipment operations during construction. There would undoubtedly be mitigation measures imposed within permits that will be required for this measure (Department of Fish and Game: 1601-1603 Stream Alteration Agreement, State Water Quality Control Board 401 Certificate of waste discharge and U.S. Army Corps of Engineers 404 Permit).

Uncertainties:
The greatest uncertainty with this measure would be the sustainability of improvements. Peak flows exceeding 100,000 cfs have occurred three times in the last 42 years. Flows of this magnitude (or perhaps even less) would probably destroy the improvements.

Cost Estimate:
Costs for this measure are difficult to estimate. It has not been determined whether or not new channels would be created or existing channels modified.
However, on a similar project proposed on the Truckee River, costs for channel excavation were on the order of $1 million/1000 feet of channel. That was a major reconstruction project and costs for this measure would likely be an order of magnitude less. Costs for revegetation on the Truckee River were on the order of $13,000/1000 feet of channel. That too, probably represents a relatively conservative (high) cost. Channel construction costs can be considerably reduced if there are no significant difficulties in achieving channel stability.

Recommendations:
One of the main factors that should be considered in evaluating the feasibility of this PM&E is the likely persistence of any habitat restorations or improvements implemented in Hatchery Ditch and Moe's Ditch. More than anything else, this will depend on the frequency, duration and amplitude of high flow events. If the LFC is to continue to receive relatively uniform flows, with only occasional extreme flows, habitat restorations

and improvements would be likely to persist for a number of years. However, even under the current flow regime, the habitats may require regular maintenance and periodic reconstruction. According to DFG staff, Moe's Ditch had to be regraded almost every year for a period after it was constructed (Koll Buer, DWR, personal communication). It has been completely destroyed and reconstructed several times. If Oroville Project operations were modified to create more frequent high flow events in the future, improvements and restoration in the habitat of the ditches could have a short life span.

Figure 1. Hatchery Ditch and Moe's Ditch

Figure 2. Hatchery Ditch: Abundant Instream Cover and Overhead Cover (top and bottom)

Figure 3. Feather River Hatchery Settling Ponds (top and bottom)

Figure 4. Hatchery Ditch: Source (top), Straight Channel with Uniform Flow (bottom)

Figure 5. Moe's Ditch: Upstream End (top), Downstream End (bottom)